Outline

Risk or Uncertainty?
Probability is powerful, but ignorance is not probabilistic

Uncertainty and the optimization imperative
• Limits of prediction and outcome-optimization
• Robust satisficing

Rural poverty and exploiting natural resources
Risk and Uncertainty

Probabilistic risk

or

Knightian “true uncertainty”
## Probabilistic Risk

<table>
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<tr>
<th>Consequence</th>
<th>Probability</th>
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<td>Drought</td>
<td>Stochastic process</td>
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<td>Industrial accident</td>
<td>Actuarial tables</td>
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<td>Tsunami</td>
<td>Historical data</td>
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<td>Faulty air filters</td>
<td>Quality control data</td>
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<tr>
<td>Deception, scam</td>
<td>Sociological data</td>
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**Risk is:**
- Structured: known event space
- Modeled with probability
- Manageable (but still risky)
Frank Knight’s “true uncertainty”

“The uncertainties which persist ... are uninsured because there is no objective measure of the probability”.

Diagram:
- Fukushima
- Arab Spring
- Russia-Crimea
- ESP
- Diagnostic lens
- 3-d printed car
Wheeler’s Island

“We live on an island of knowledge surrounded by a sea of ignorance. As our island of knowledge grows, so does the shore of our ignorance.”

John A. Wheeler
Non-probabilistic true uncertainty

Discovery

- America
- Nuclear fission
- Martians (not yet?)
Non-probabilistic true uncertainty

D Discovery

I Invention/Innovation

- Printing press: material invention.
- Ecological responsibility: conceptual innovation.
- French revolution: social innovation.
Non-probabilistic true uncertainty

D Discovery

I Invention/Innovation

S Surprise (Asymmetric uncertainty)
  - Ambush
  - Competitor’s innovation
  - Natural catastrophe
Non-probabilistic true uncertainty

D Discovery
I Invention/Innovation
S Surprise (Asymmetric uncertainty)

What’s the next D I or S ???

Knightian uncertainty:
• Unstructured: unknown event space.
• Indeterminate: no laws.
• Barely manageable.
Shackle-Popper

Indeterminism

Shackle-Popper Indeterminism

Intelligence:
What people know, influences how they behave.

Discovery:
What will be discovered tomorrow can’t be known today.

Indeterminism:
Tomorrow's behavior can’t be fully modelled today.

• Info-gaps, indeterminism: unpredictable.
• Ignorance is not probabilistic.
Uncertainty and the Optimization Imperative

Doing your best:
What does that mean?
• Outcome optimization.
• Procedural optimization.

Implications for decision making:
Robust satisficing.
Doing Your Best

Substantive outcome optimization:
- Predict outcomes of available options.
- Select predicted best option.
Substantive outcome optimization.

Useful under risk:

• Structured uncertainty.
• Reliable probabilistic predictions.
Substantive outcome optimization:

Useful under risk.

Not useful (irresponsible?) under uncertainty.

• Unstructured uncertainty.
• Unreliable predictions.
Questions

What do we (not) know?

Robustness questions:
• What is an essential outcome?
• How to be robust to surprise?

Opportuneness questions:
• What is a windfall outcome?
• How to exploit opportunities?

How to prioritize decision options?

What are the trade offs?
Answers

**Robustness answer:**

- System model
- Outcome requirement
- Uncertainty model

**Opportuneness answer:**

- System model
- Outcome aspiration
- Uncertainty model

Robustness function → Prioritized options

Opportuneness function → Prioritized options
Robust Satisficing

Two questions for decision makers:
1. What are our goals?
2. How much error/surprise can we tolerate?
Robust Satisficing

Two questions for decision makers:

1. What are our goals?
2. How much error/surprise can we tolerate?

   - Essential goals.
   - Worst acceptable outcomes.
   - Modest or ambitious.
Robust Satisficing

Two questions for decision makers:

1. What are our goals?
2. How much error/surprise can we tolerate?


2. Robustness:
   • Immunity to ignorance.
   • Greatest tolerable error or surprise.
Robust Satisficing

Two questions for decision makers:
1. What are our goals?
2. How much error/surprise can we tolerate?


2. Robustness: Greatest tolerable error.

Optimize robustness; satisfice goals:
Procedural (not substantive) optimization.
Rural poverty & resource use

Rural poverty:
- Low agricultural productivity.
- High mortality/morbidity.
- Resentment and suspicion of government and NGOs.
- Local barons or warlords.

Innovative hi-tech proposal:
- New strains of plants.
- Better irrigation.
- Better fertilizers.
- Mechanization of field work.
Innovation dilemma of poverty

Potential gains of innovative resource exploitation:
- Higher agricultural productivity.
- Higher standard of living.
- Less arduous field work.

Potential losses of innovative resource exploitation:
- Failure of innovative crops, causing starvation.
- Social reorganization and upheaval.
- Rapid population growth, canceling gains (Malthus).

**Dilemma:** Innovation could be much better, or much worse. How to choose?
Innovation dilemma of poverty

Basic questions:
• What are the goals?
• What is our knowledge?
• What are the uncertainties?

Robustness of an option:
Maximum tolerable uncertainty.

The knowledge-bifurcation. Is your knowledge:
• Quantitative: data and equations?
• Qualitative: mainly insight and understanding, (perhaps with some numbers)?

We will consider both situations.
Poverty dilemma: quantitative

Field study of traditional State of the Art:
- Survival requirement: 1171 kg wheat/ha.
- Probability dist. of productivity well known.
- Survival probability: 0.95 (known).
- Survival catastrophe return-time: 20 years (known).

Knowledge about innovative option:
- Probability distribution of productivity estimated, uncertain.
- Survival probability: 0.9967 (estimate).
- Survival catastrophe return-time: 303 years (estimate).

The choice is clear?
Poverty dilemma: quantitative

Uncertainty of innovative option:
• Prob. distribution of productivity: estimated.
• True tail (rare but bad): highly uncertain.
• Survival probability & catastrophe return-time may be much greater than for SotA.

Robustness of an option: How much error can we tolerate?
Greatest uncertainty at which current knowledge satisfies the survival requirement.

Robust prioritization: Innovation or SotA?
• Maximize robustness, satisfice outcome.
• Don’t try to optimize the outcome.
Poverty dilemma: quantitative

Robustness of innovative option:

Pessimist's thm. Trade off:
Higher survival prob $\leftrightarrow$ lower robustness

Zeroing: No robustness at estimated survival probability.

Robustness of SotA:
- Unbounded for survival probability up to 0.95.
- Zero for survival probability above 0.95.

Decision: Choose by robustly satisfying the requirement.
Poverty dilemma: quantitative

Summary of quantitative analysis of innov. dilemma:

- **Zeroing:** no robustness at estimated survival prob.
- **Optimizer’s fallacy:** Prioritize by estimates.
- **Trade off:** robustness vs survival probability.
- **Preference reversal:** Resolution of dilemma.
Poverty dilemma: qualitative

Now for the hard part:

Qualitative analysis of robustness.

Robustness:
- We can’t evaluate it quantitatively.
- Assess it qualitatively with proxies for robustness:
  - Resilience: rapid recovery of critical functions.
  - Redundancy: multiple alternative solutions.
  - Flexibility: rapid modification of tools and methods.
  - Adaptiveness: adjust goals and methods online.
  - Comprehensiveness: interdisciplinary system-wide coherence.
Basic questions:

• What are the goals?
• What is our knowledge?
• What are the uncertainties?

Bernard Amadei: girl water carriers.

• Goal: more potable water.
• Knowledge: Abundant fuel. Pump tech. Local culture.
• Uncertainties:
  – Long-term maintenance? Catastrophe if not.
  – Stable fuel supply?
  – Social response: what happens to the girls?
Poverty dilemma: qualitative

Robust solution:

- **Satisfice** the goal. Don’t try to maximize. (Exploit trade off.)
- **Co-design**: local involvement in all stages (comprehensive).
- **Train** locals in pump maintenance (resilience, flexibility).
- **Transition period** of dual supply (redundancy).
- **Long-term contact** for emergency support (adaptiveness).
- **Education** for girls (and boys) (comprehensiveness).
- **Quantitative** analysis where possible.
Poverty dilemma: qualitative

Methodological re-cap:

• **Trade off**: higher ambition = lower robustness.
  Ambitions: Yes. Wishful thinking: No.

• **Zeroing**: Best-estimated outcomes have no robustness.
  **Satisfice** your goals. **Optimize** your robustness.
  Don’t try to maximize the outcome.

• **Preference reversal**: sub-optimal may be more robust.
  Wood burning steam pump more robust to uncertainty than solar electric technology.
Summing Up

Risk or Uncertainty:
- Probabilistic risk, Knightian uncertainty (info-gaps).
- Shackle-Popper indeterminism.

Substantive outcome optimization:
Useful under risk, not under uncertainty.

Robust satisficing: Optimize robustness; satisfice goals.
- Procedural (not substantive) optimization.

Opportune windfalling: use propitious uncertainty.

Rural poverty and exploiting natural resources.